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Scaling laws for direct laser acceleration with radiation reaction

MARTIN JIRKA[1], IOP of the CAS, ELI-Beamlines Project, Na Slovance 2, 18221 Prague, Czech Republic, MARIJA VRANIC, THOMAS GRISMAYER, LUIS O. SILVA, GoLP/IPFN, Instituto Superior Tecnico, University of Lisbon, Lisbon, 1049-001, Portugal — Electrons can be directly accelerated by a laser within a hollow (or low density) plasma channel. If betatron resonance is achieved, we can expect to obtain multi-GeV electron energies. However, this acceleration process is very sensitive to the local initial conditions. By increasing the laser intensity, it is possible to enter a regime where radiation reaction becomes important in the particle dynamics, which further complicates the analysis. In this case, the particles can radiate away a considerable fraction of their energy, and their acceleration is limited by this emission. However, radiation reaction can also be beneficial for the acceleration process, as it allows for radiative electron trapping and changes the onset of the betatron resonance by altering the local conditions. Here, we study the direct laser acceleration within a plasma channel using the parameters of the upcoming generation of 10 PW-class lasers. We show that even with radiation reaction, it is possible to obtain multi-GeV electrons in a single-stage acceleration within a 0.5 mm-long channel provided that the optimal initial conditions are satisfied. We present those conditions in a form of explicit analytical scaling laws that can be applied to guide the future electron acceleration experiments.

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